Photo: Daniel E. Lee, http://www.flickr.com/photos/dlee13/7609077916

Macaroons

Cookies with Contextual Caveats for Decentralized Authorization in the Cloud

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The Problem

- Cookies (and similar tokens) are ubiquitous in cloud authorization
- Good reasons: Simple, easily adopted
- But cookies are easy to steal, carry broad authority, and lack flexibility
- Macaroons = Better cookies, with arbitrary *caveats*, i.e. restrictions on access

Cookies with integrity

Standard technique:

Protect cookies with a MAC

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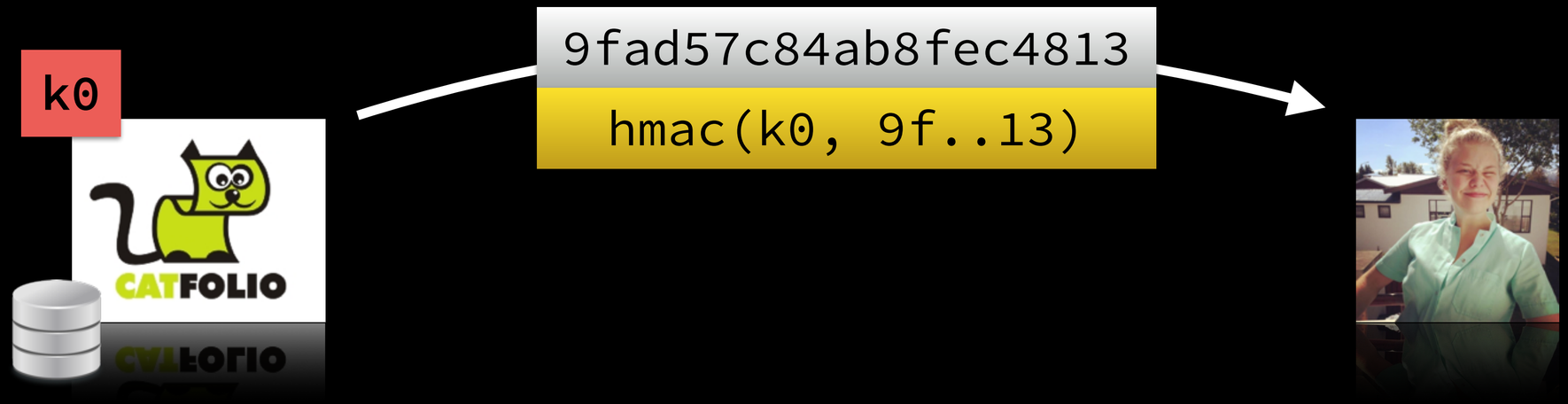

Cookies with integrity

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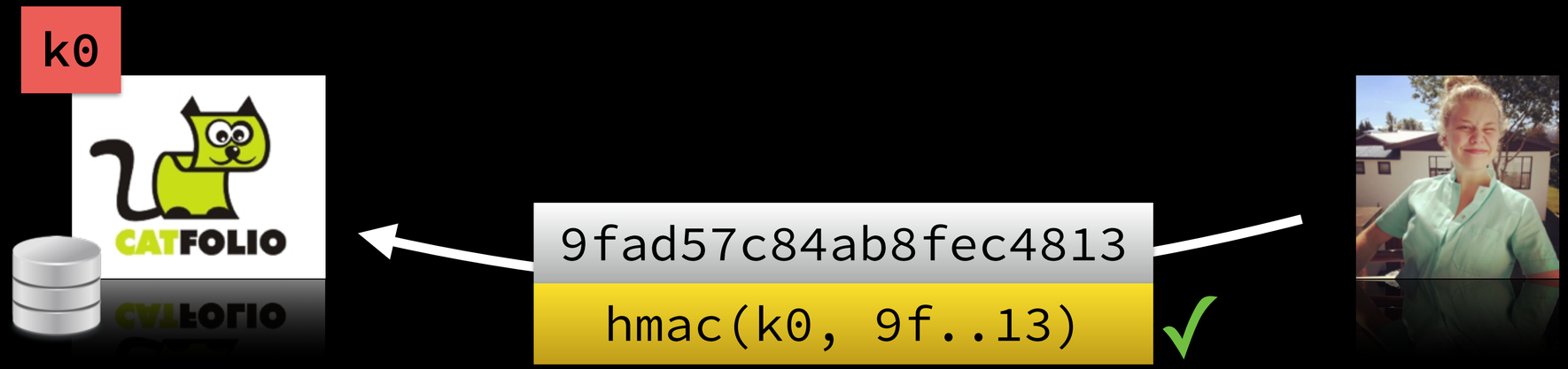

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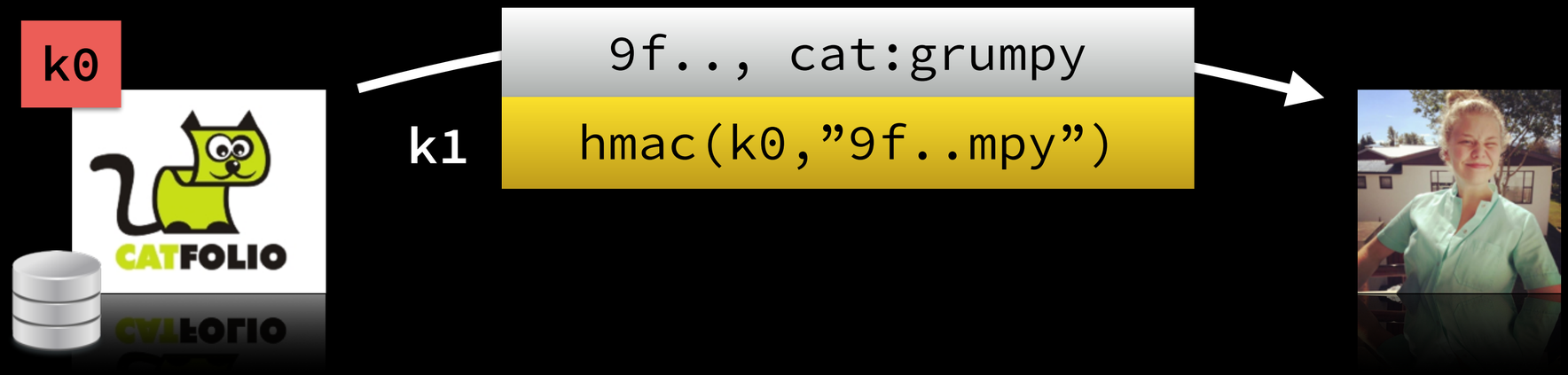
Hash-chaining

- Key enabling idea, dating back to Amoeba
- Macaroon: Key identifier + caveats + signature



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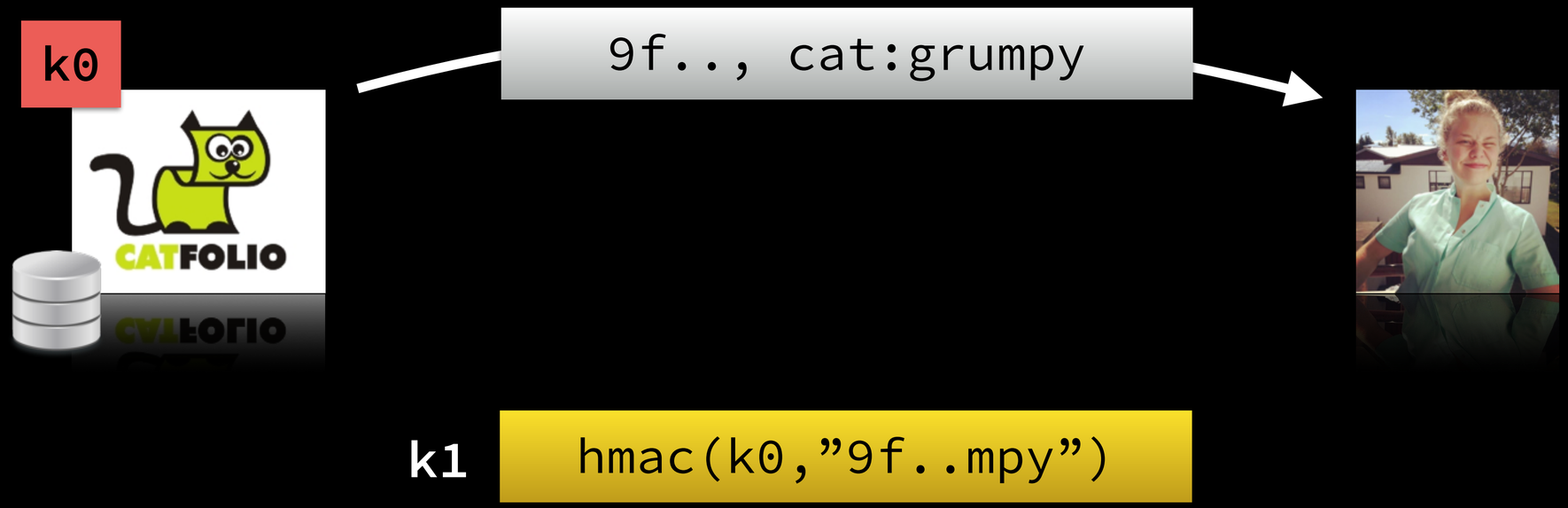

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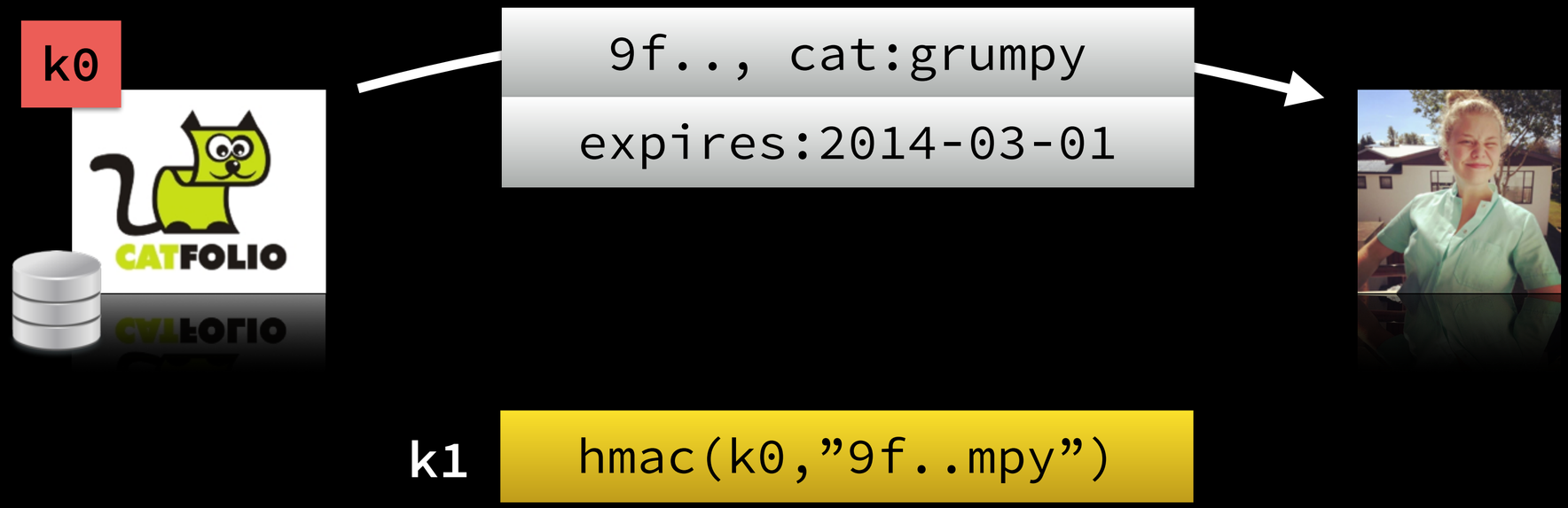

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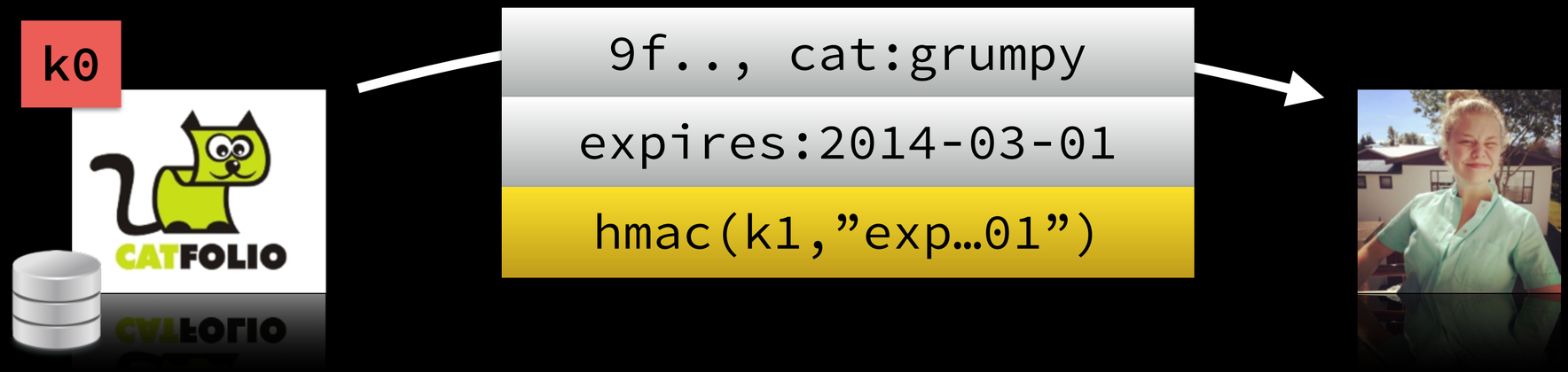

Verification

- Verify integrity by recomputing signature

```
9f.., cat:grumpy
expires:2014-03-01
fe3228a0bcee79
```

Verification

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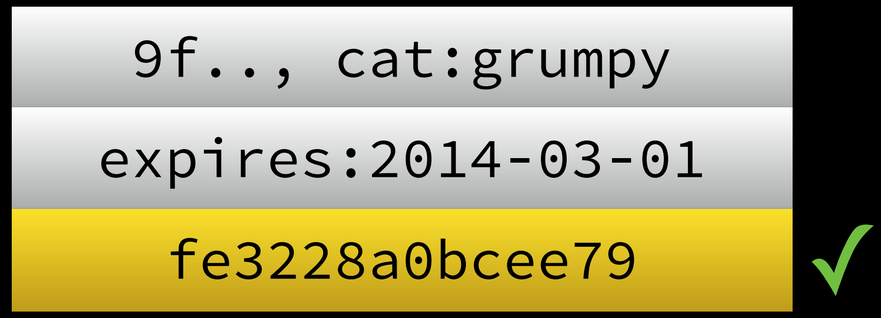
```
hmac( k0 , 9f.., cat:grumpy ) = k1
hmac( k1 , expires:2014-03-01 ) = k2
k2 == fe3228a0bcee79 ✓
```

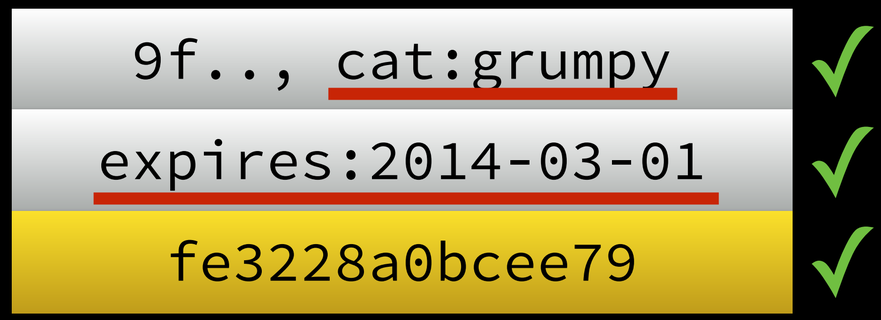
Verification

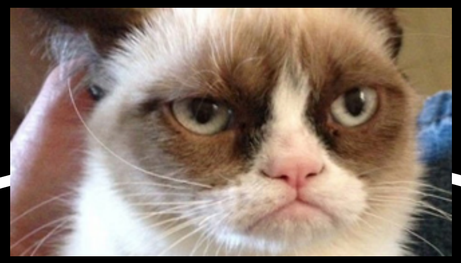
- Verify integrity by recomputing signature



Verification

- Verify integrity by recomputing signature
- Check that all caveats are satisfied





9f.., cat:grumpy ✓

expires:2014-03-01 ✓

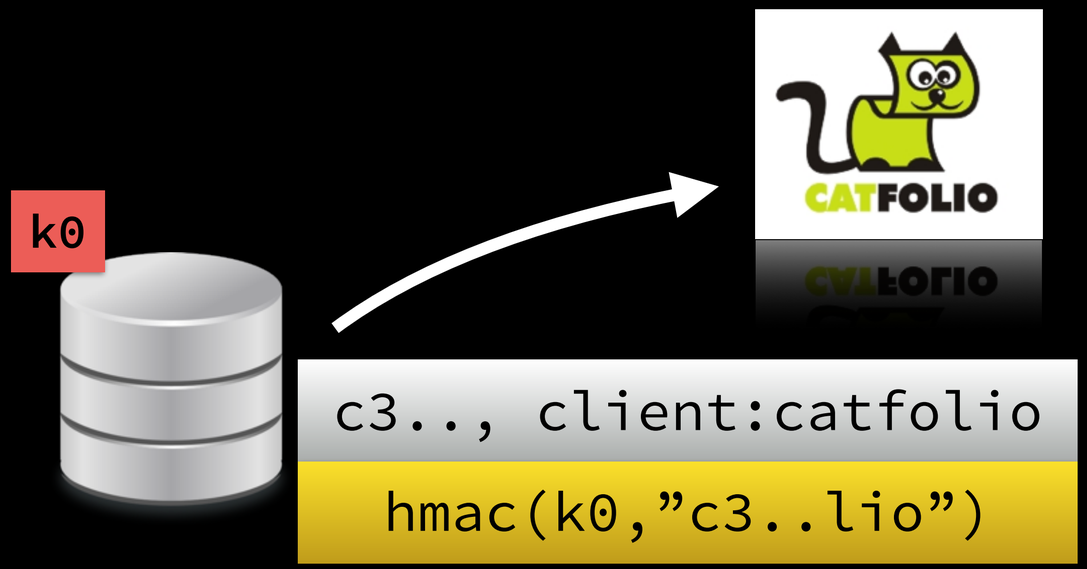
fe3228a0bcee79 ✓

First-party caveats

- Can be added by any holder of a macaroon
- No constraints on the assertion language
- Naturally support attenuation and delegation

Delegation

Delegation



Delegation

c3.., client:catfolio

hmac(k0,”c3..lio”)

Delegation

c3.., client:catfolio

filename:grumpy.jpg

hmac(k1,”fil…jpg”)

Delegation

c3.., client:catfolio

filename:grumpy.jpg

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Delegation

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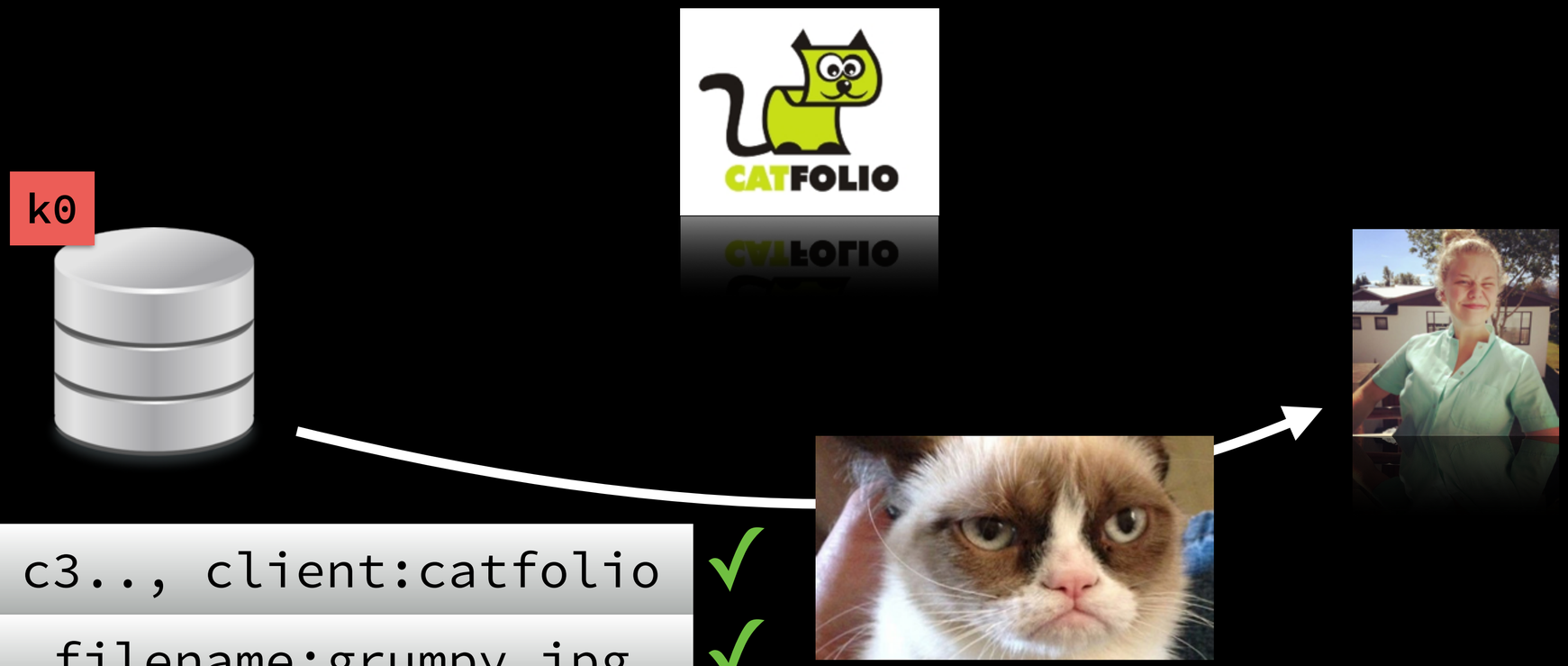
Delegation

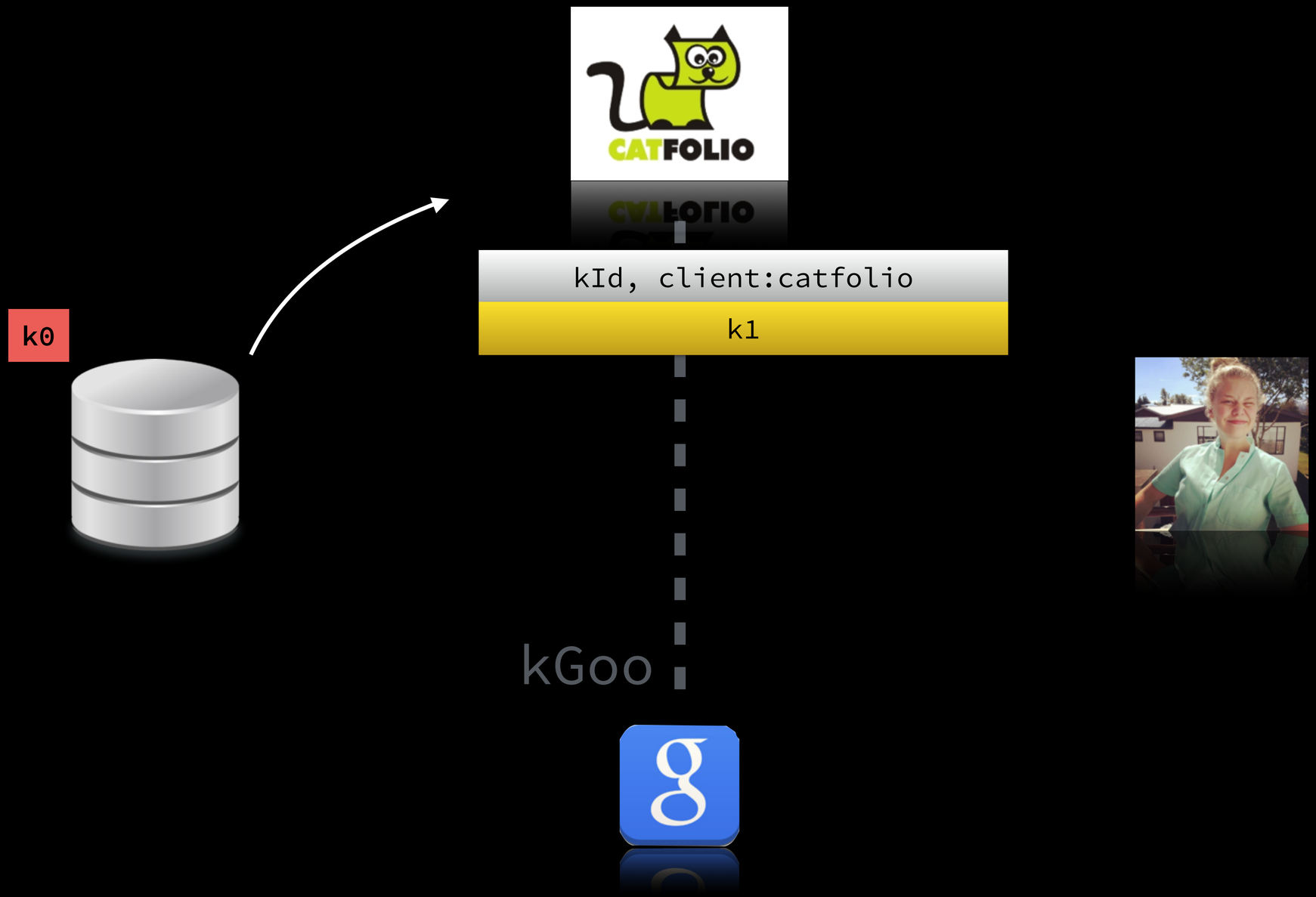

k0
CATFOLIO
c3.., client:catfolio
filename:grumpy.jpg
hmac(k1,”fil…jpg”)

Third-party caveats

- So far, only the target server is trusted for authorization decisions.
- Third-party caveats require another service to check restrictions.

k0

kGoo


CATFOLIO
kId, client:catfolio
k1
k0
kGoo

kId, client:catfolio

filename:grumpy.jpg

k2

k0

kGoo

kC

kId, client:catfolio

filename:grumpy.jpg

E(k2,kC) | E(kGoo,kC:catlovr)

k3

k0

kGoo

kC

kId, client:catpics

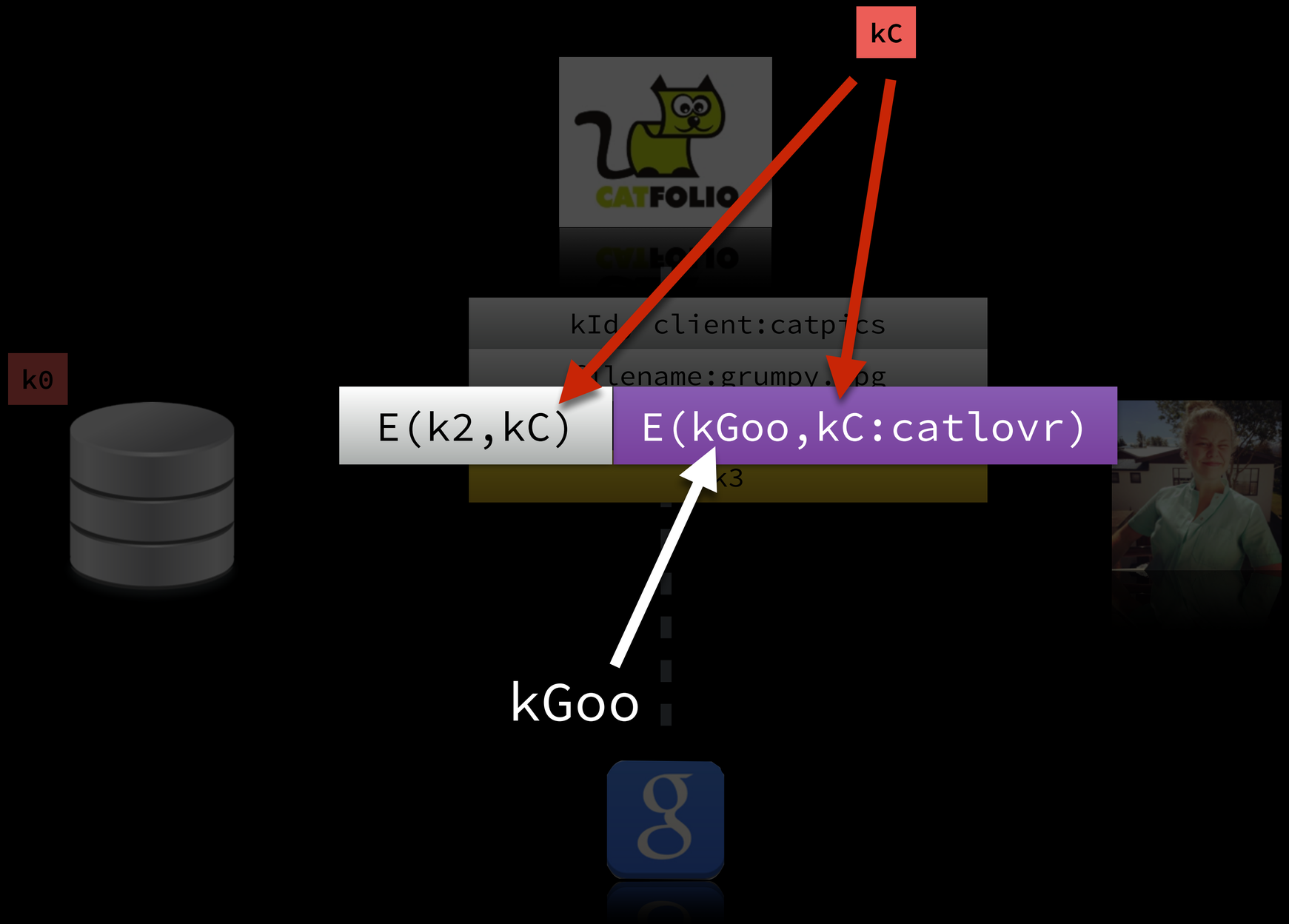
filename:grumpy.jpg

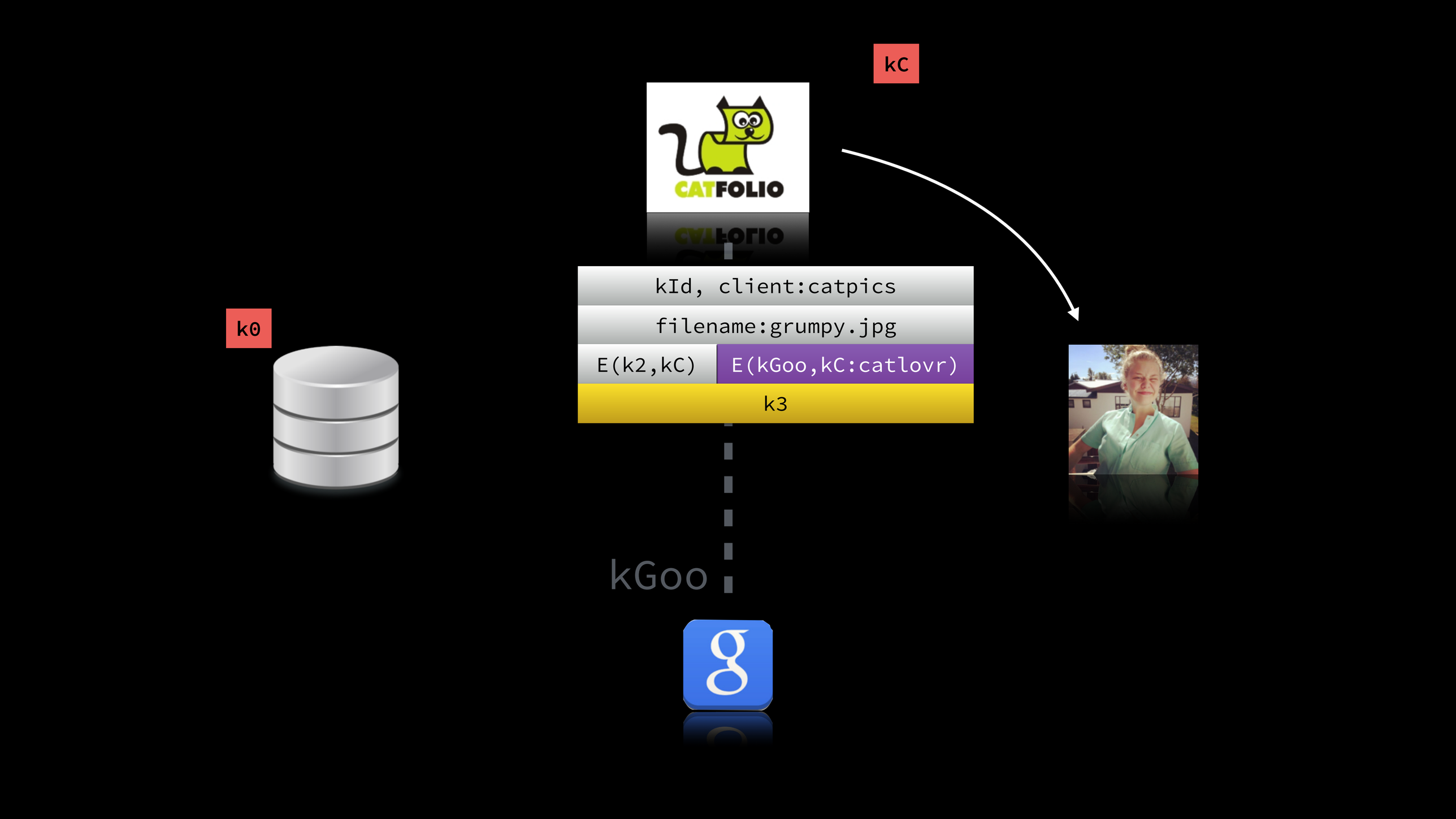
E(k2,kC) | E(kGoo,kC:catlovr)

k3

k0

kGoo


kC
CATFOLIO
kId, client:catpics
filename:grumpy.jpg
k0
E(k2,kC)
E(kGoo,kC:catlovr)
k3
kGoo


kC
CATFOLIO
kId, client:catpics
filename:grumpy.jpg
E(k2,kC)
E(kGoo,kC:catlovr)
k3
k0
kGoo

kC

kId, client:catpics	
filename:grumpy.jpg	
E(k2,kC)	E(kGoo,kC:catlovr)
k3	

k0

E(kGoo, kC:catlovr)

kGoo

kC

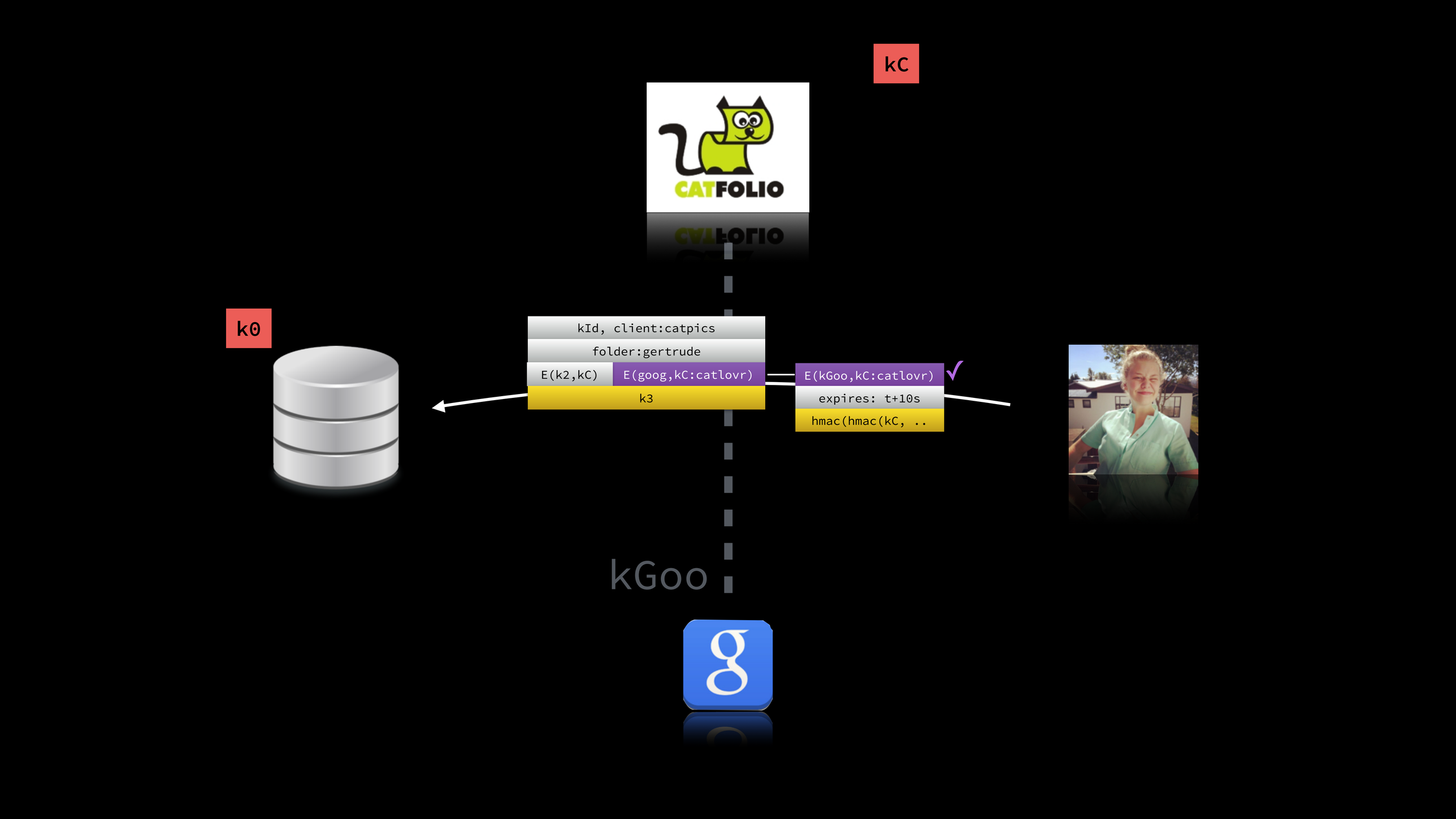
kId, client:catpics	
filename:grumpy.jpg	
E(k2,kC)	E(goog,kC:catlovr)
k3	

k0

kGoo

E(kGoo, kC:catlovr)
expires: t+10s
hmac(hmac(kC, ..

kC


kC
CATFOLIO
k0
kId, client:catpics
folder:gertrude
E(k2,kC)
E(goog,kC:catlovr)
k3
E(kGoo,kC:catlovr)
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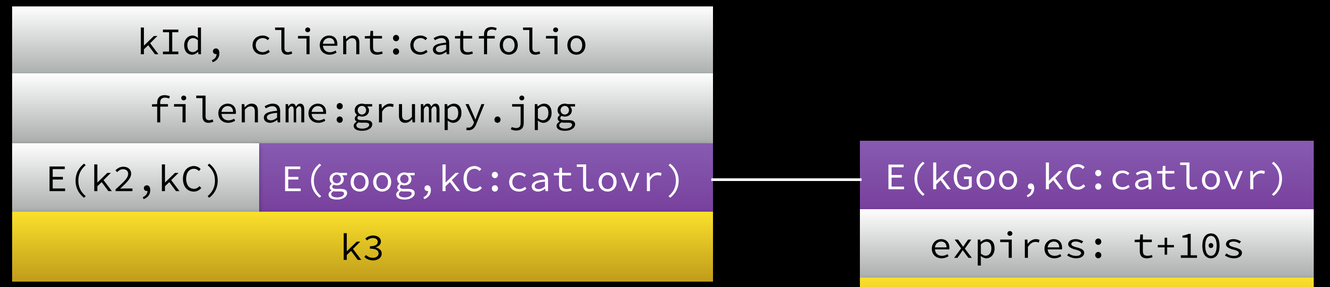
hmac(hmac(kC, ..
kGoo

Verification

- As before, check signature & caveats
- For each third-party caveat, recursively:
  - Verify its discharge macaroon
  - Check discharge macaroon caveats



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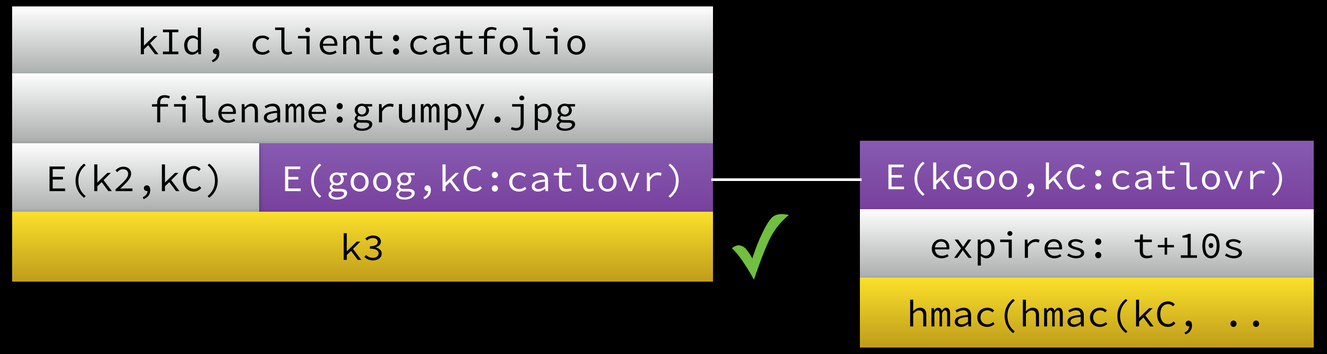

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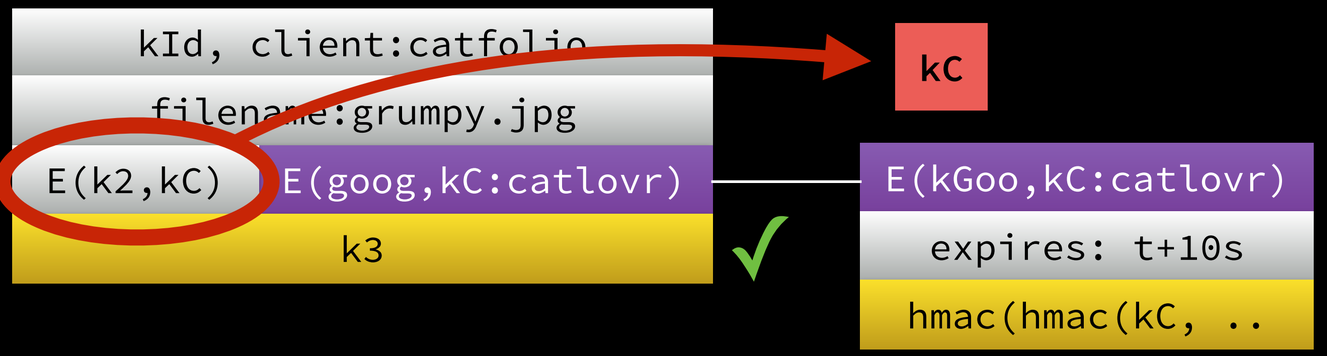

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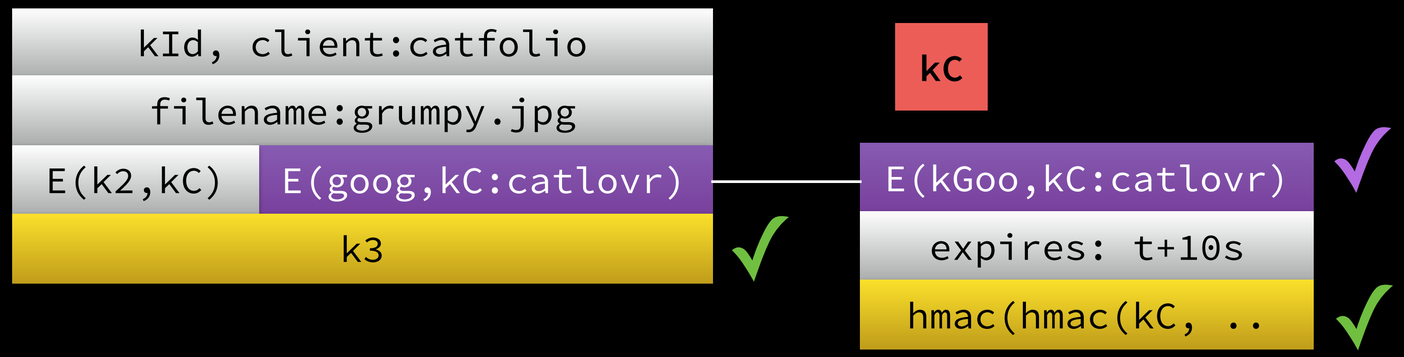

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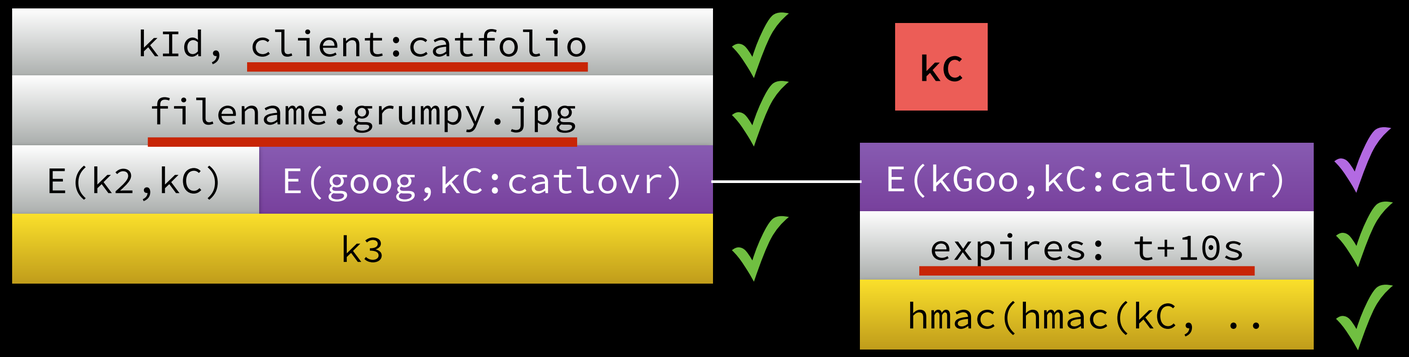


Benefits

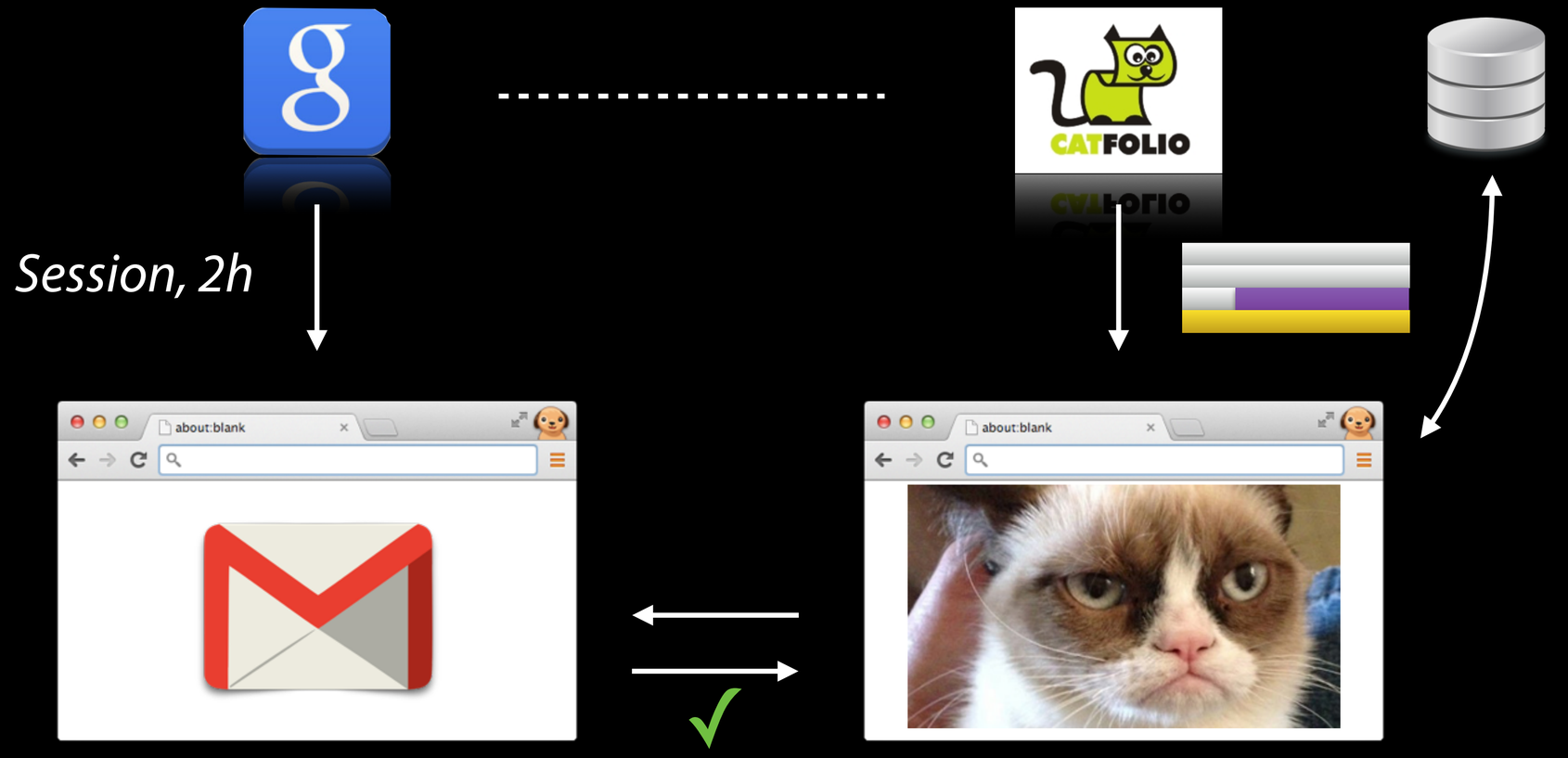
Speed: HMACs = Very light-weight, and fast.

Timeliness: Can require fresh credentials and revocation checks on every request.

Flexibility: Contextual confinements, attenuation, delegation, third-party caveats.

Adoptability: HMACs can run anywhere.

Example: Identity



Example: Identity

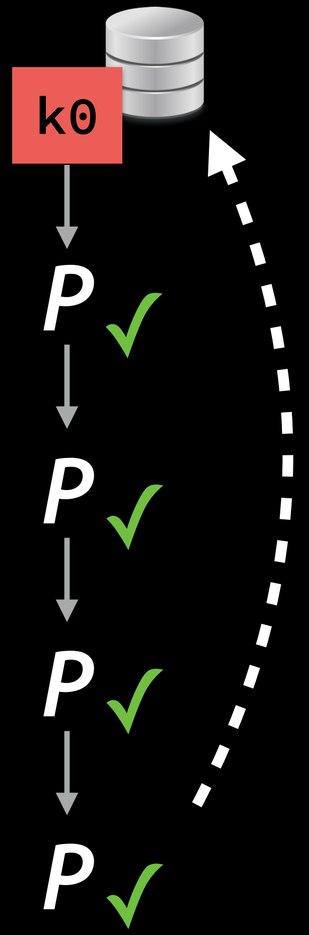
Logged
out

Performance

	JS/Chrome	Node.js
Minting	27 µs	19 µs
Add caveat	~300 µs	56 µs
Verify	~360 µs	70 µs
To/from JSON	~3.5 µs	~4.0 µs

Performance

	JS/Chrome	Node.js
Minting	37k /s	53k /s
Add caveat	3.3k /s	18k /s
Verify	3.7k /s	14k /s
To/from JSON	380k /s	250k /s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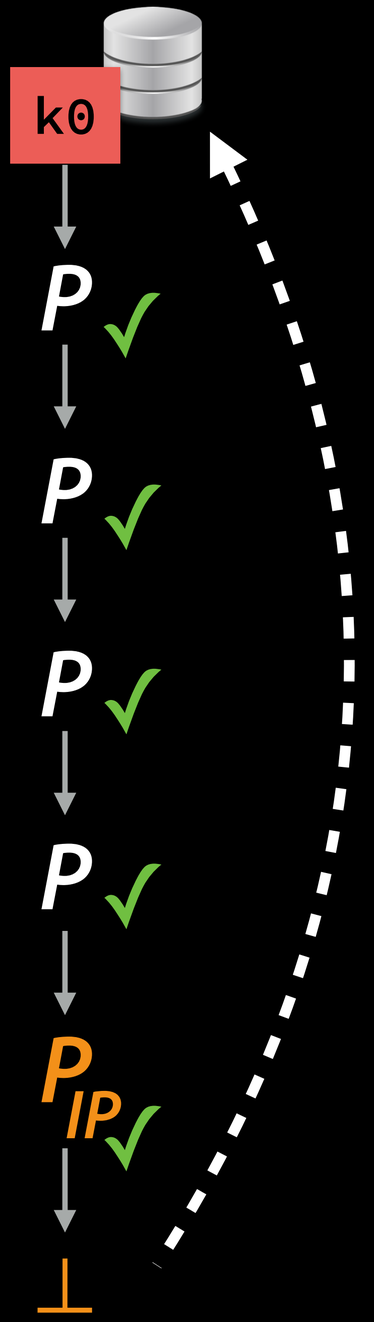
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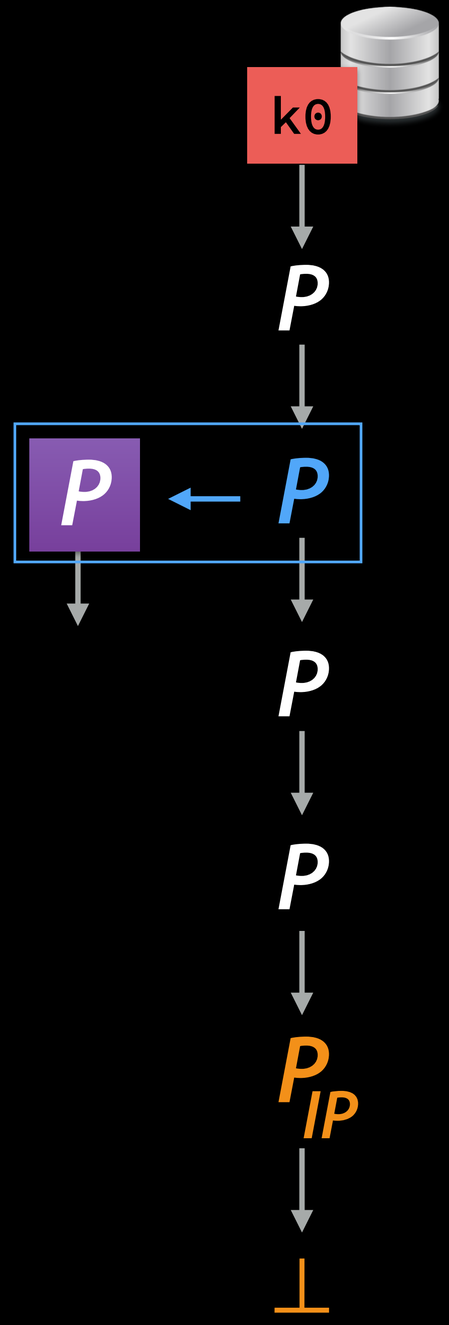
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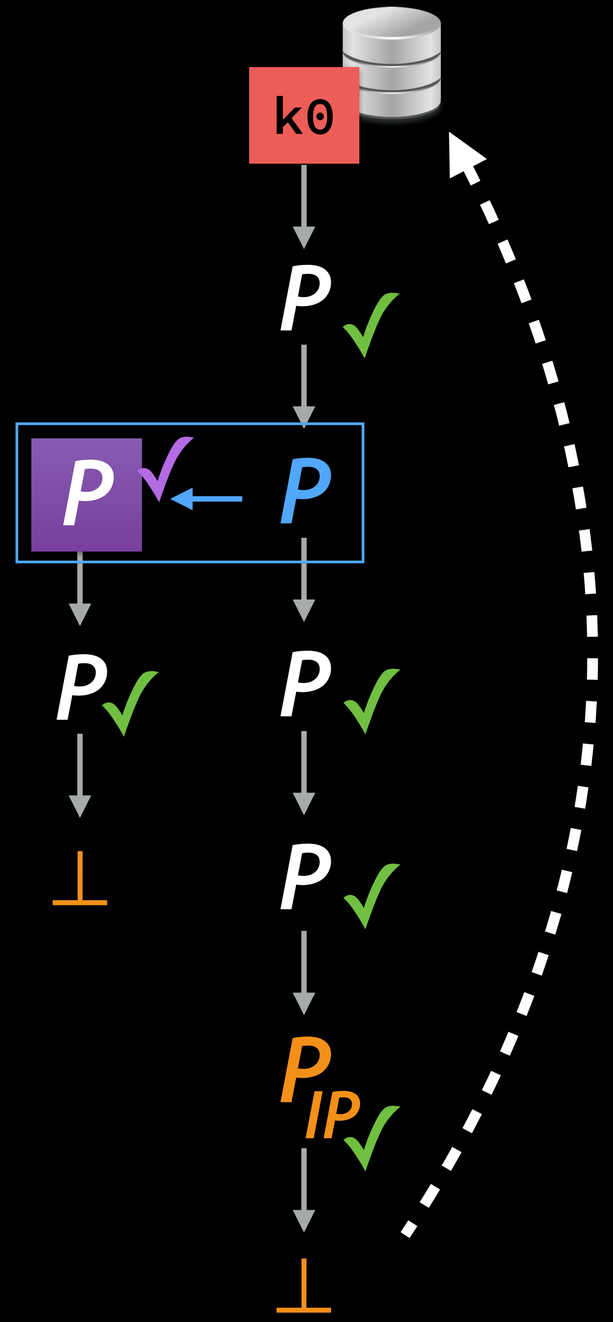
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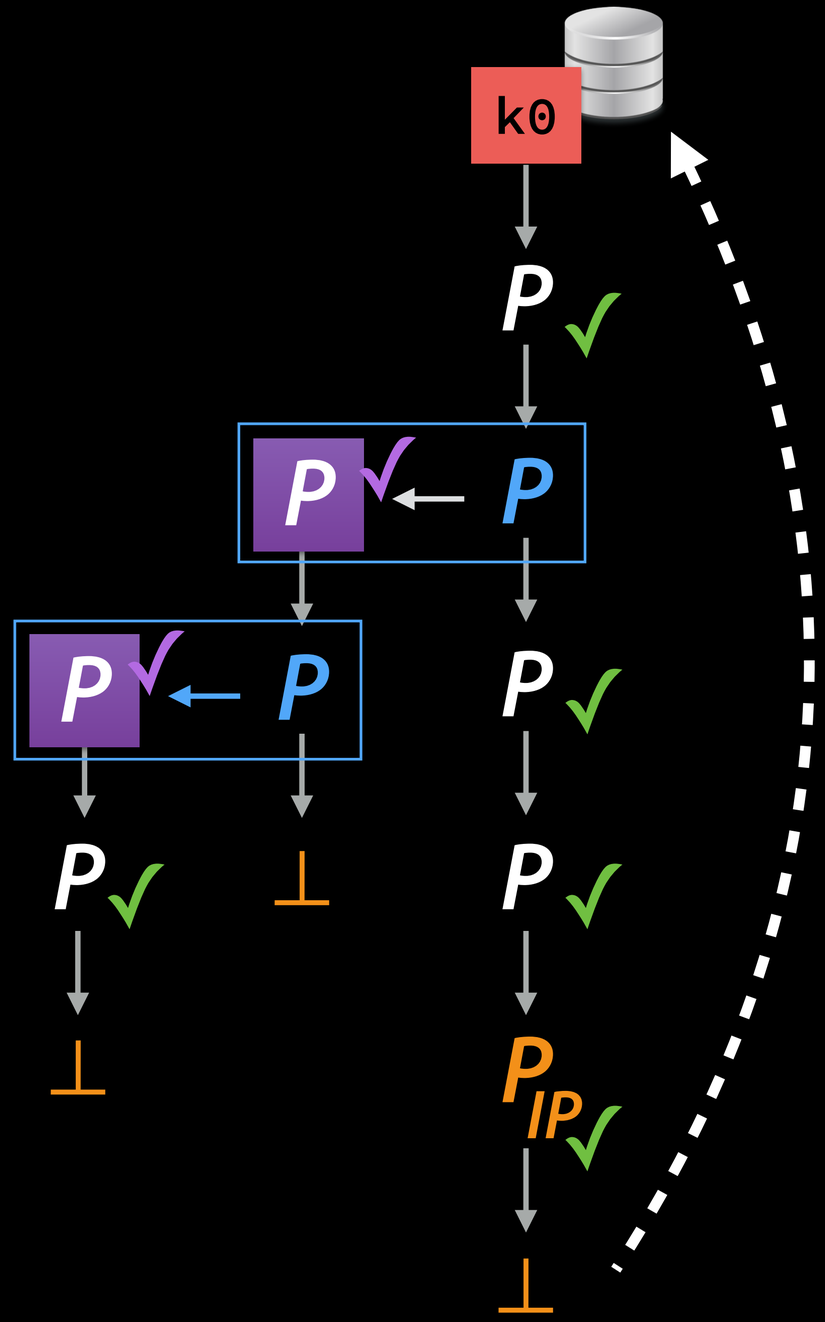
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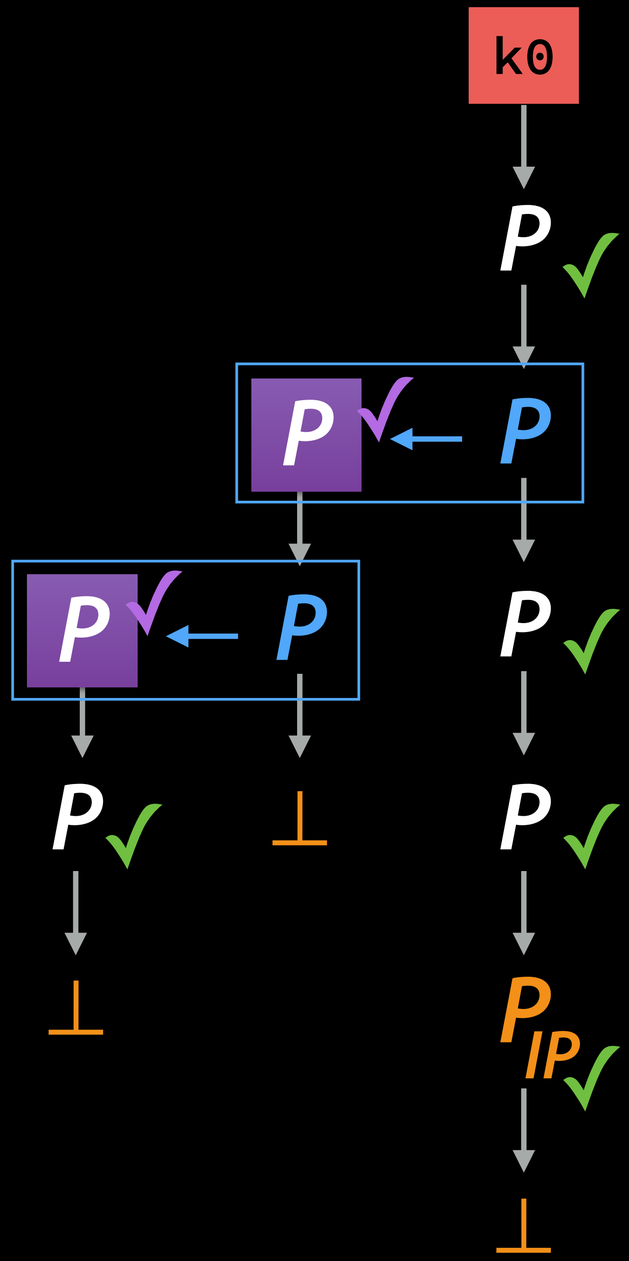
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Fun stuff in the paper

- Formal definitions and verification
- A variant based on public-key crypto instead of hash-chains
- Comparison to SPKI/SDSI
- Other uses for first- and third-party caveats

TL;DR

- Macaroons are better cookies.
- Fast: Can be used anywhere, often.
- Flexible: Fit many applications, delegable.
- Secure:
  Caveats limit scope; Contextual caveats make stolen macaroons useless.